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(54) COMPOSITE MATERIALS

(71) We, Glyco - Metall - Werke Daelen & Loos G.m.b.H., a German limited liability company, of 62 Wiesbaden-Schierstein, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a composite structure, for example for friction or sliding elements, with a metal support and a sliding layer thereon of synthetic plastics material capable of high thermal loading, and containing thermosetting polyimide resin and optionally additives such as molybdenum disulphide or a metal sliding bearing alloy, for improving running properties.

Composite sliding bearings are known wherein a layer of polyamide, provided with perforations or depressions, is glued by acrylic epoxide adhesive to a steel support body, the perforations or depressions being filled with a mixture of solid lubricant and a bearing metal. These known bearings with a layer of polyamide have disadvantages in that the adhesives used do not make it possible to exploit the high thermal loading capacity of the polyamide.

An object of the invention therefore is to provide a composite structure with a polyimide-containing sliding layer which does not have the disadvantages of the known polyamide sliding bearings. Sliding elements manufactured from such composite structure have good sliding, high temperature resistance, and permit largely maintenance-free operation. In addition, the structure can be easy and inexpensive to manufacture and capable of being readily processed when sliding elements are being manufactured.

According to this invention, a composite structure comprises a metal support and a sliding layer carried by the support, wherein the sliding layer includes granular and/or powdered polyimide resin in a hardened polyimide lacquer which bonds the sliding layer to the support.

Compared with the known composite sliding bearings with polyimide materials, the sliding layer of the structure of the invention is more intensely homogenised. This applies particularly to the heat conductive constituents in the sliding layer, so that dissipation of heat from the working surface of the sliding layer is even practically all over the surface. The invention also provides a bond between the constituents of the sliding layer and between the layer itself and the metal support, the bond being adapted in its resistance to temperature to the polyimide in the sliding layer.

In this respect, the invention is based on the knowledge that lacquer-like polyimides which are soluble in solvents also have adequately good running properties, so that the polyimide lacquer can be used as a binder in the whole sliding layer, up and including the working surface of the sliding element in question.

The sliding layer may contain 20 to 70% by weight of thermosetting polyimide powder or granules and 80 to 30% by weight of self-lubricating additives.

The polyimide powder or granules and/or the polyimide lacquer constituent can be substances from one or more of the following groups pf polyimides: carboranimide, hydrogen-free polyimides, poly-triazo-pyromelliticimides, polyester-imides and polyamidimides. The polyimide resins and/or polyimide lacquer consituents can be copolymers of imide monomers.

An additive to improve the sliding properties may for example be powdered graphite, or molybdenum disulphide or oxide. In the region of the connecting surface where the sliding layer is joined to the support, a supporting gauze, for example of a sliding bearing material, mah be embed-

ded in the sliding layer. Such a supporting gauze may be of tin-bronze.

The support may, on its side which carries the sliding layer, be covered with a sintered porous structure, made preferably from a sliding material. In this way the connection between the support and the sliding layer can be strengthened. Moreover, the sintered porous structure affords an increase in the mechanical loading properties similar to the above-mentioned supporting gauze. Sliding bearings are known which have a working surface of a porous metal structure filled with polytetrafluoroethylene alone or in combination with metallic or non-metallic additives. Such sliding bearing can operate without maintenance at temperatures up to approximately 280°C. For manufacturing such sliding bearings, it is known initially to produce a porous structure by sintering a spherically powdered metal onto the metallic support body and then to apply polytetrafluoroethylene powder and metal powder, in the form of a powder, paste or dispersion, or as a strip, onto the porous structure, into which it is caused to penetrate by pressure and temperature. In the manufacture of the porous structure, the sintering temperature must be sufficiently high to achieve an adequately rigid bond between the spherical powder and the metallic carrier on the one hand and among the individual spheres of powder. The known sliding bearings in which the porous structure is filled with polytetrafluoroethylene do however have disadvantages which are overcome if the porous structure is filled with polyimide resin stirred into polyimide lacquer. Polytetrafluoroethylene, unlike thermoplastic materials, does not become molten at elevated temperature; instead, above its transformation point of about 300°C, it is transformed into a gel-like state. Therefore, the interaction of high pressure and temperature is required to fill the porous structure with polytetrafluoroethylene. The pressure applied should not be too great, as otherwise the pores in the porous structure can become irreversibly closed. In contrast, polyimide resin which is blended into polyimide lacquer can be given a relatively low viscosity, so that the porous structure is relatively more easily impregnated with such a mixture.

Also this disadvantage is eliminated by the filling according to the invention. The thermal load capacity of the sliding bearings with a porous structure and a polyimide filling is substantially higher than with sliding bearings, the porous structure of which is filled with polytetrafluoroethylene. In particular, in the case of sliding bearings with a polyimide filling in the porous structure, the temperature of continuous usage drops markedly, but not so greatly with a relatively high mechanical loading on the bearing as is the case with sliding bearings in which the porous structure is filled with tetrafluoroethylene.

The relatively simple and reliable incorporation of polyimide into the porous structure also affords the opportunity of having the support formed solely by a sintered porous structure, preferably of a bearing alloy.

The support may also be a perforated steel or bronze plate.

The invention makes it possible for the thickness of the sliding layer to be greater, so that the working layer on the composite structure or sliding elements manufactured therefrom can be machined by a cutting process. For example, the thickness of the working layer may be 0.1 to 0.5 mm. In contrast, the thickness of the sliding layer on a bearing with a porous structure filled with polytetrafluoroethylene is approximately 0.020 mm. The substantially greater thickness of the sliding layer also provides a substantially longer working life for sliding elements manufactured from the structure of the invention.

In a method of manufacturing a composite structure according to the invention, polyimide lacquer, granular or powdered polyimide resin and an additive for improving the sliding properties of the sliding layer are intimately blended and homogenised to a low-viscosity to pastry form, and the mixture thus prepared is spread over the support in the quantity corresponding to the required layer thickness, and is hardened. In a preferred embodiment of the method, the strip forming the support and a supporting gauze are laid continuously on each other and are continuously coated with the homogenised mixture of polyimide lacquer, polyimide resin and additive. In machining, it is possible for the sliding layer to be peeled to a predetermined close-tolerance final thickness once it has hardened. For manufacture of sliding elements of small radius, it is recommended that the sliding layer be initially only partially hardened on the support strip and be machined by cutting to the required final thickness, sliding elements being formed from this material, after which the sliding surface on the sliding element is fully hardened.

Embodiments of the invention will be described by way of example, with reference to the attched drawings, in which:—

Figures 1 to 3 are enlarged sections through composite structures; and

Figure 4 is a diagram of apparatus for making the composite structure of Figure 1.

Referring to Figure 1, a gauze 2 of tin-bronze bearing material is laid on the steel

support 1. This gauze 2 is penetrated by a mixture of polyimide particles 3, graphite particles 4 and a composition 5 of hardened polyimide lacquer which holds together the particles 3 and 4 and the gauze 2, bonding them securely to the support 1.

Referring to Figure 2, a sintered porous bronze structure 6 is applied to a steel support 1. The sintered structure 6 is impregnated with a mixture of polyimide particles 3, graphite particles 4 and a composition 5 of hardened polyimide lacquer which holds the particles together and bonds them securely to the sintered structure 6 and the support 1.

Referring to Figure 3, a perforated steel plate support 1, is coated on one side with a mixture made from polyimide particles 3, graphite particles 4 and a composition 5 of polyimide lacquer for holding the particles together, the mixture of particles 3 and 4 and lacquer 5 penetrating the holes in the support 1.

The support may be in the form of an inlay within the layer of particles 3 and 4 and the bonding layer composition 5. The inlay could be in the form of a tin-bronze gauge like the gauze 2, or it could be a self-supporting structure in the form of a layer of sintered bronze. Such inlay will provide the necessary mechanical strength for the composite structure.

The thickness of the applied sliding layer, particularly in Figures 1 and 3, is approximately 0.15 to 0.5 mm. This thickness, and the nature of the layer, make possible a cutting type of machining on the sliding bearing surface.

For manufacturing the composite material of the invention, the method illustrated in Figure 4 may be used. Referring to Figure 4 a metal support strip 12 is unreeled from a roll 11 and a support gauze 14 of tin-bronze bearing alloy, is unreeled from a roll 13. The support 12 and the support gauze 14 are laid one on the other by a roller 15, or between a pair of rollers, and are then pulled under a dispensing and coating device. The latter has a hopper 16 which is closed off in the upstream direction by a slide 17. In low viscosity to pasty form, a mixture of polyimide lacquer, polyimide particles and additive is contained in the hopper 16. The mixture is constantly blended by an agitator 18. Downstream of the hopper 16 is a scraper 19 by which the required layer thickness is adjusted. Downstream of the scraper 19, the coated support 12 with the support gauze 14 embedded into the layer formed by the mixture, passes through an oven 20 equipped with extraction means. In the zone of this oven hardening of the applied sliding layer, as well as its connection to the support gauze 14 and the metal support 12, is carried out. There follows a water cooling apparatus 21. Alternatively air cooling could be used. A cutting machining operation, using a planing cutter 22, produces the final thickness. Lastly, the completely machined strip is passed around a roller 23 and wound onto a bobbin 24.

Example 1

41 parts by weight of a resin solution of polyimide lacquer are blended with 28 parts by weight of a finely powdered mixture of 35% by weight polybismaleinimide and 25% by weight of graphite, 17 parts by weight N-methylolpyrrolidone and 11 parts by weight of xylene, and homogenised in a three-roller mill. The resultant mixture is, using the above-described method, applied to the metal support 12 while the tin-bronze gauze 14 0.1 mm thick and of mesh size 0.060 mm is also applied, the layer being adjusted to a thickness of 0.35 mm. After heating for 1½ minutes at 300°C, air or water is used for cooling and the strip is planed to adjust to a required layer thickness, with a tolerance of ± 0.01 mm. Sliding bearings may be produced from this strip and permit maintenance-free operation up to 300°C.

Example 2

The composition of the mixture is the same as, and application onto the metal support 12 and support gauze 14 take place in the same way as, in Example 1. The applied layer reinforced by the support gauze 14 is initially hardened to 180°C for 1½ minutes. The partly-hardened layer can, as in Example 1, be adjusted to the required thickness by the planing cutter. Sliding bearings produced from the strip-form composite structure thus prepared can be passed in mass through a continuous sintering over for 1½ minutes, the layer being hardened at a temperature of 300°C and thus acquiring its optimum properties. The latter procedure is recommended particularly where small radii frictional sliding elements are to be manufactured.

WHAT WE CLAIM IS:—

1. A composite structure comprising a metal support and a sliding layer carried by the support, wherein the sliding layer includes granular and/or powdered polyimide resin in a hardened polyimide lacquer which bonds the sliding layer to the support.

2. A structure according to claim 1, wherein the sliding layer includes an additive for improving the sliding properties of the layer.

3. A structure according to claim 2, wherein the additive is polytetrafluoroethylene or a metal sliding bearing alloy.

4. A structure according to claim 2 or

claim 3, wherein the polyimide resin and the additive are in the form of a powdered mixture.

5. A structure according to claim 2, wherein the layer has a total content of polyimide resin of from 20 to 70% by weight and a content of from 80 to 30% by weight of additive.

6. A structure according to any preceding claim, wherein the granular or powdered polyimide resin and/or the polyimide constituent of the lacquer are substances from one or a plurality of the following groups of polyimides: carboranimide, hydrogen-free polyimide, poly-triazo-pyromelliticimides, polyesterimides and polyamidimides.

7. A structure according to any of claims 1 to 5, wherein the granular or powered polyimide resin and/or the polyimide constituent of the lacquer are copolymers of imide monomers.

8. A structure according to claim 2, wherein the additive is powdered graphite, or molybdenum disulphide or oxide.

9. A structure according to any preceding claim, wherein, in the region of the connecting surface between the sliding layer and the support, a supporting gauze made of a sliding bearing material is embedded in the sliding layer.

10. A structure according to claim 9, wherein the supporting gauze is of tin-bronze.

11. A structure according to any of claims 1 to 8, wherein the support is coated, on the side carrying the sliding layer, with a sintered porous structure.

12. A structure according to any of claims 1 to 8, wherein the support is a sintered porous structure.

13. A structure according to any of claims 1 to 11, wherein the support is a perforated steel or bronze plate.

14. A structure according to any preceding claim, wherein the sliding layer is 0.1 to 0.5 mm thick and has a planed working surface.

15. A method of manufacturing a composite structure according to claim 2, wherein polyimide lacquer, granular or powdered polyimide resin, and additive are mixed and homogenised to a low viscosity to pasty form, the thus prepared mixture being spread over a metal strip support in the quantity corresponding to a required thickness, and hardened thereon.

16. A method according to claim 15, wherein the strip forming the support and a strip of supporting gauze are laid continuously on each other and are continuously coated with the prepared mixture.

17. A method according to claim 15 or 16, wherein the hardened sliding layer is planed to a final thickness.

18. A method according to claim 15 or claim 16 for manufacturing a sliding element, wherein the sliding layer is initially only partially hardened on the support and is machined to a required thickness, the sliding element being formed from the composite structure, and the sliding layer on the sliding element being then fully hardened.

19. A method according to any of claims 15 to 18, wherein, for preparing the mixture of polyimide lacquer, granular or powdered polyimide resin and additive, 14 parts by weight of a lacquer-like resin solution of a polyimide are mixed with 28 parts by weight of a mixture of 75% by weight of a granular or powdered polybismaleinimide and 25% by weight graphite, 17 parts by weight N-methylpyrrolidone, and 11 parts by weight xylene, and homogenised in mill.

20. A method according to claim 19, wherein the mixture is hardened on the support at a temperature of substantially 300°C for 1½ minutes.

21. A method according to claim 19, for manufacture of a sliding bearing, wherein the mixture is applied to the support and is preliminarily hardened on the support at a temperature of approximately 180°C over a period of approximately 1½ minutes and is then hardened at a temperature of approximately 300°C over a period of approximately 1½ minutes after the sliding bearing has been formed.

22. A composite structure substantially as herein described with reference to the accompanying drawings.

23. A method of making a composite structure substantially as herein described with reference to the accompanying drawings.

WITHERS & ROGERS
Chartered Patent Agents
148-150 Holborn,
London, EC1N 2NT
Agents for the Applicant

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FIG. 1

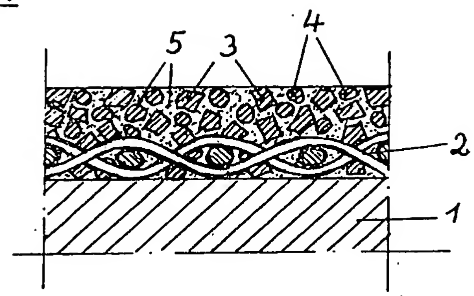


FIG. 2

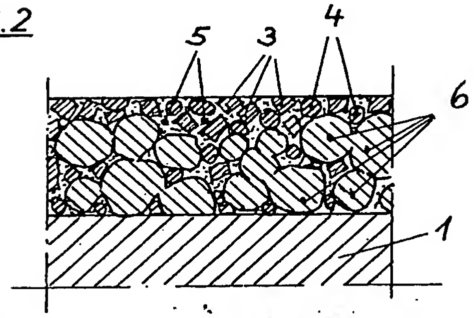
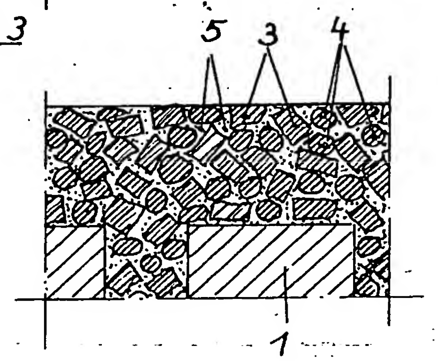


FIG. 3



1415100 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

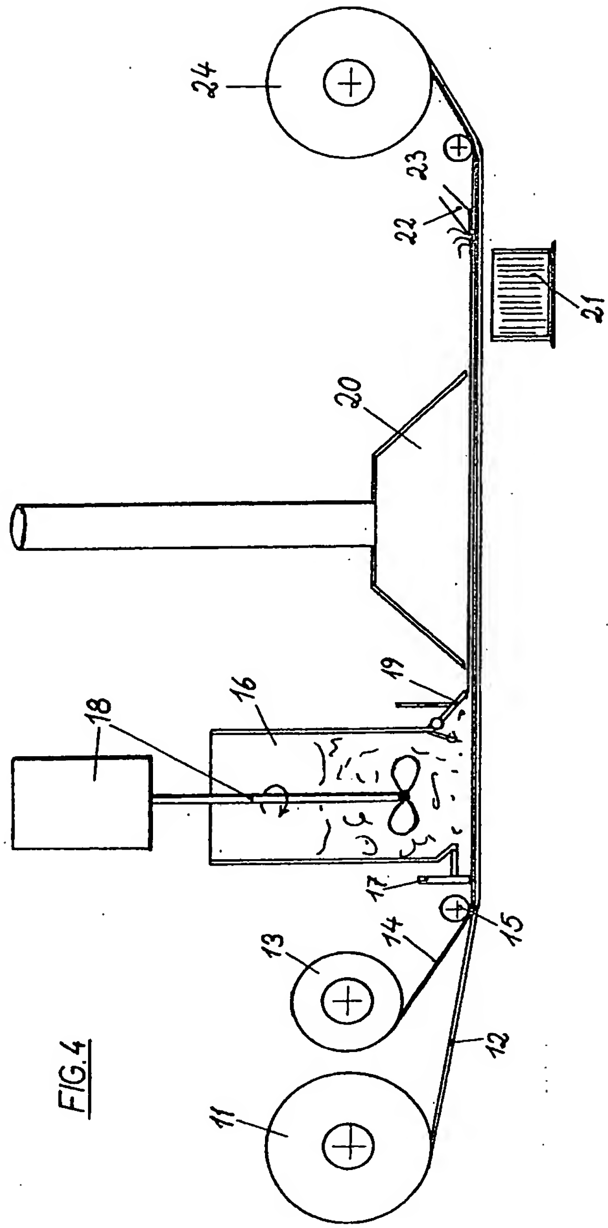


FIG.4